

Pauropus furcifer Silvestri (Pauropodidae, Pauropoda): towards an adaptation for life in caves

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Pauropus furcifer Silvestri (Pauropodidae, Pauropoda): towards an adaptation for life in caves. - A cave-dwelling population of *Pauropus furcifer* Silvestri (Pauropodidae, Pauropoda) has been found in the Zlotska Pećina Cave, near Bor, East Serbia, Yugoslavia. Some morphological traits of the specimens studied may demonstrate adaptations of this population for life underground. Additionally, some taxonomical and biogeographical features of this pauropod species have been discussed in view of the evolution of the underground karst relief in the Balkan Peninsula.

Key-words: taxonomy - biogeography - evolution - cave fauna - Pauropoda.

INTRODUCTION

Despite the enormous growth of ecological investigations in recent decades, pauropods have seldom received attention. This is remarkable because they inhabit strata from litter to subsoil and are more or less associated with many groups of soil-living organisms. The reasons may be their small body size, scattered literature, and anticipated low population density. Another reason, probably responsible for the low number of records in the biospeleological literature, is that pauropods still are unfamiliar to many, even well-trained soil zoologists. Thus, so far only 13 species (out of about 650) have been found in natural caves and mines.

CAVE-INHABITING PAUROPODA IN EX-YUGOSLAVIA

It is well-known that some species of cave-inhabiting animals occur in exceedingly low population densities while others may occur in remarkably high numbers. The Pauropoda probably belong to the former group and seem to be rare in caves, but there is no doubt that a number of subterranean species still remain to be discovered.

Only two reports from Yugoslav caves have previously been published and those by REMY (1938: 160) and by REMY & HUSSON (1938: 3) are probably the first ones. They reported one adult female of *Pauropus furcifer* Silvestri, collected in Hercegovina (now Bosnia - Hercegovina) in 1936, 10 m from the entrance of the Šipovica Cave (Blagaj, near Mostar). Well over 20 years later ATTEMS (1959: 284, 285, 298, 319 and 397), in his report on cave animals from the Balkan Peninsula collected by Prof. Karel Absolon, published a second find: a single specimen of *Trachypauropus latzeli* (Cook) from the Bosnian cave Ivan-Pass on Mt. Ozren, near Sarajevo (REMY 1962: 75). The species reported below, *P. furcifer*, has been collected in a natural cave once earlier, in La Preste, the cave Sainte-Marie, in Pyrénées Orientales in southern France (REMY 1961) and is known also from the catacombs in Paris (REMY 1961: 86).

REMY (1962: 75) reported a single female from the Ivan-Pass Cave. Because he did not note any adaptation for life in caves, his specimen probably was epigeal and had moved into the cave recently or had been introduced there. However, the specimens reported in this study, the first ones from a Serbian cave, were collected in the deeper part of a natural cave and exhibit some morphological traits which indicate adaptations for life underground.

SYSTEMATIC PART

Order Hexamerocerata

Family Pauropodidae

***Pauropus furcifer* Silvestri, 1902**

(Figs 1 and 2)

Material examined: One male, one female, and two subadult females, from the Zlotska Pećina Cave or Gaura Lazari Cave), village of Zlot, near Bor, East Serbia, Yugoslavia; 21-22 October 1995, collected by R.N. Dimitrijević, L.R. Lučić and S.E. Makarov. The adults are deposited in the collections of the Institute of Zoology, Faculty of Biology, University of Belgrade, Belgrade, Yugoslavia; the subadults in the collections of the Muséum d'histoire naturelle, Geneva, Switzerland.

Taxonomical remarks: Although no other comparison except on the basis of literature data and our own analyses of numerous specimens from adjacent countries (mainly Greece and Italy) have been made, it is apparent that the specimens from the Zlotska Pećina Cave show clear dissimilarities if compared to their apparently conspecific and epigeal forms; these differences indicate adaptations to the life in caves. Comparisons have been made only with the adult specimens.

A n t e n n a e . The ratio of the length of the flagellum F_1 of the tergal antennal branch to the length of the branch itself is higher than in epigeal specimens (2.3 - 2.5 vs. 1.9 - 2.0).

P y g i d i u m . Though the set of setae is not fully complete, the following observations are of importance. The a_2 and a_3 of the tergum are proportionally thin and the a_3 are 2.8 times as long as the a_1 vs. 1.9 - 2.5 in epigeal specimens. The *st* are

proportionally long and thin, more pointed and also glabrous; the ratio $st-st / st$ is 1.2 vs. 1.4 - 1.7 in epigean material. The pubescence of the setae is conspicuously faint (Fig. 1).

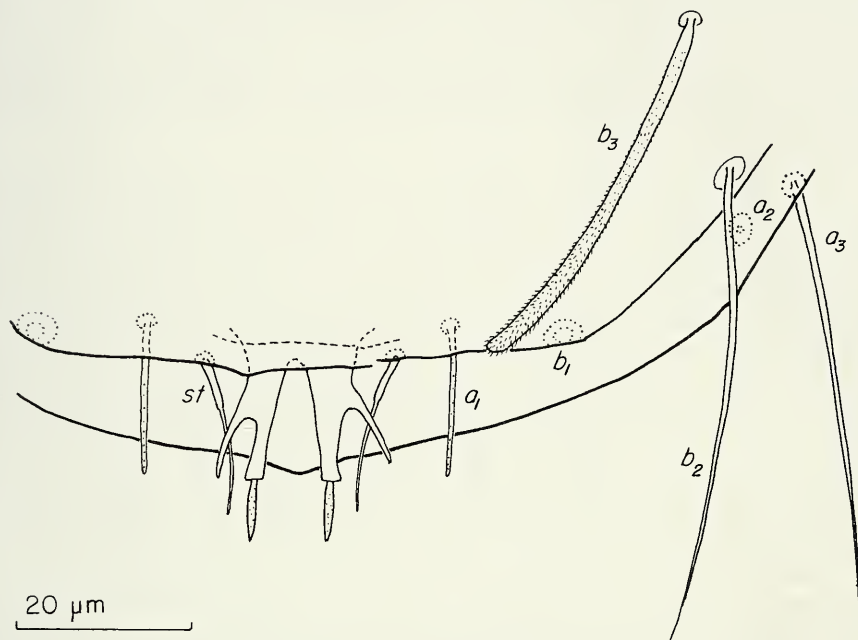


FIG. 1

Pauropus furcifer Silvestri. Adult male, from the Zlotska Pećina Cave, East Serbia, Yugoslavia. Pygidium, posterior and left part, sternal view.

The sternum too has deviating characters. The b_3 are distinctly thickened and have not the typical end-swelling of epigean specimens. A slight thickening has been stated earlier but then only in combination with an end-swelling. The anal plate is quite glabrous disregarding the distal appendages which are faintly granular.

In comparison with epigean specimens the pygidium and its setae have remarkably delicate pubescence or are quite glabrous.

General distribution: The species is West Palaearctic and is known from Great Britain, Belgium, Germany, France, Switzerland, Austria, Czech Republic, Bulgaria, Roumania, Andorra, Portugal, ex-Yugoslavia (Bosnia - Hercegovina), Spain, Italy, Greece and Algeria. Records from outside West Palaearctic (Natal, REMY 1959; New Zealand, REMY 1952) are most dubious. From the former country, Remy reported a single very defective *Pauropus* specimen, the anal plate of which is resembling the *furcifer* plate, and from the latter a juvenile specimen in very bad condition lacking the antennal branches, trichobothria, and the main part of the tergal setae.

DISCUSSION AND CONCLUSIONS

The karst terrains of East Serbia are characterized by an extremely complex and variable surface relief. The landscape is dominated by the typical karst phenomena as well as by the presence of polymorphic karstic elements (ČURČIĆ 1990; GAVRILOVIĆ 1989). The karstic process took place in Mesozoic limestone and dolostone rocks. While the Cretaceous limestones are more abundant, the Triassic ones are less frequent. Cenozoic formations, however, are also widely distributed (ČURČIĆ 1990; GAVRILOVIĆ 1965). These are represented mainly by the Oligocene and Neogene lacustrine sediments.

The Zlotska Pećina Cave is located on the slopes of Mt. Kučaj on the left bank of the Lazareva Dolina which is the deepest and narrowest canyon in East Serbia. This cave was formed in the limestones of the Lower Cretaceous age; actually, it is a complex underground system, a net of complicated channels and corridors. The total length of all passages is over 1,600 m (PETROVIĆ & GAVRILOVIĆ 1965; PETROVIĆ 1958), and these constitute several levels. The morphological evolution of the main channel had been largely affected by the hydrological evolution of an underground stream; due to subsequent karstification, the upper channels became dry and fossilized while the underground water is now circulating in the lowest cave horizon, which is inaccessible for visitors (PETROVIĆ 1958; GAVRILOVIĆ 1975). The cave was formed during the late diluvial phase, or at the end of the Pleistocene, when the climate changed from humid and cold into arid and warm (PETROVIĆ 1958).

The specimens of *P. furcifer* were found about 200-220 m from the entrance in deep, humid and dark channels of the cave, either on small parts of rotten wood or under stones. The occurrence of subadults indicates that the life cycle is gone through in the cave. This is strongly supported by some clear adaptations to the life underground, e.g.: the elongation of the pygidial setae (*st*), the thickening of *b*₃, the reduction of pubescence (compared with the epigeal forms from the Balkans), as well as the elongations in the antennae (Figs 1 and 2). Therefore, it is evident that *P. furcifer* is presently in a phase of actively colonizing a cave.

It is evident that the pauropods studied lived or originated in areas or geological epochs with a humid climate. With increasing aridity and the formation of different niches underground, this species evolved as a cave inhabitant too. Therefore, adaptation to the life in deep soil and in caves is not characteristic of a particular taxonomic group of animals but rather represents an adaptive response of the epigeal and humicolous species, including pauropods, in order to survive in the conditions of a typical or modified Mediterranean climate.

Another item is worth mentioning here. The Zlotska Pećina Cave is inhabited by more than 20 different endemic and relict invertebrates including representatives of copepods, ostracods, isopods, diplopods, pseudoscorpions, collembolans, diplurans, thysanurans, and coleopterans; to these we may add the pauropods. It is already known that the better an area was sheltered from unfavourable changes, the richer it is in relict forms. This is precisely the case with the Zlot cave system. However, the question of the direct provenance of its fauna still remains open. We have every

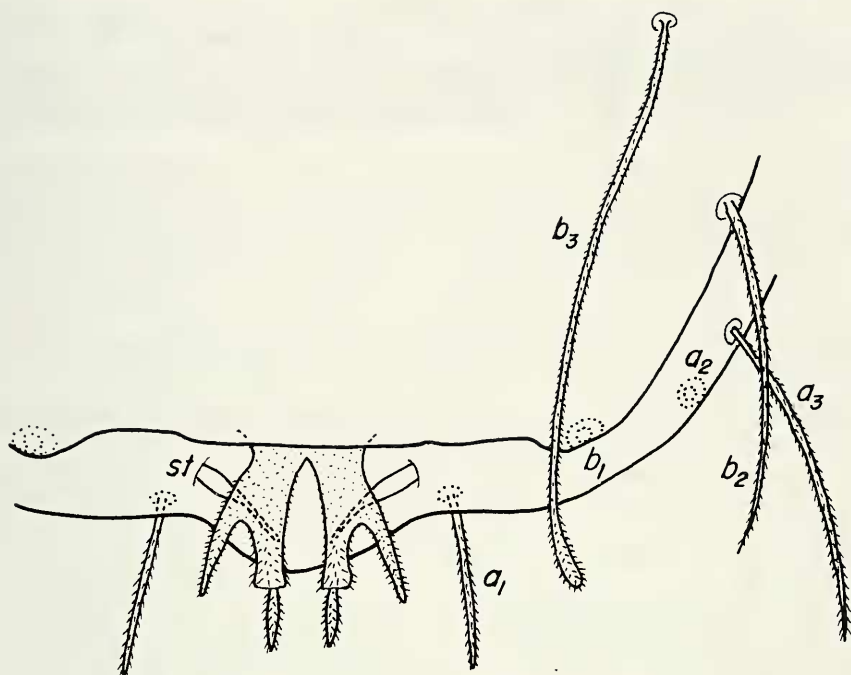


FIG. 2

Pauropus furcifer Silvestri. Adult epigean female, from Greece (Corfu, Pantokrator Massif, between Perithia and Lautse). Pygidium, posterior and left part, sternal view. Scale as in Fig. 1.

reason to assume that this living world evolved from the ancient circum-Mediterranean fauna, its origin to be sought in the proto-Balkan region (ĆURČIĆ 1986, 1988).

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